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Rethinking *Value* in the Bio-economy: Finance, Assetization, and the Management of Value

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Abstract

Current debates in science and technology studies emphasize that the bio-economy—or, the articulation of capitalism and biotechnology—is built on notions of commodity production, commodification, and materiality, emphasizing that it is possible to derive value from body parts, molecular and cellular tissues, biological processes, and so on. What is missing from these perspectives, however, is consideration of the political-economic actors, knowledges, and practices involved in the creation and management of value. As part of a rethinking of value in the bio-economy, this article analyzes three key political-economic processes: financialization, capitalization, and assetization. In doing so, it argues that value is managed as part of a series of valuation practices, it is not inherent in biological materialities.

Keywords

bio-economy, value, valuation, finance, assetization, biotechnology

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Introduction

> More than a third—twenty-nine companies—of the [UK] listed biotech sector have gone bust since 2008 and ten are on the brink, according to work by Paul Cuddon at analysts Peel Hunt. Another thirty-eight are "fine" and six were bought by other companies. (*The Guardian*, August 29, 2011)

As the opening quote above indicates, part of the fallout from the 2007-2008 global financial crisis (GFC) was the (partial) collapse of the life sciences sector, not only in the UK but also worldwide. All forms of financing in the global life sciences were affected by the GFC, from venture capital (VC) through to initial public offerings (IPO); for example, the number of global IPOs dropped to under ten in 2008 (Huggett and Lähteenmäki 2012). Interestingly, global market capitalization declined during the same period, yet the global "biotech" industry achieved profitability *for the first time ever* in 2009 (Ernst & Young [EY] 2015a). By 2014, moreover, global market capitalization of the biotech industry had soared to over US$1 trillion (EY 2015a). Despite rising market capitalization, however, in 2014 the life sciences sector was neither producing proportionally more products and services nor proportionally higher revenues than four or five years earlier. While these figures hide significant details—for example, only ten US life science firms represent US$600 billion of global market capitalization—they illustrate how uncertain and volatile value *and* valuations are in the bio-economy, and how disassociated they can often seem to be from the development of new products and services. This uncertainty and volatility is reinforced by the more recent negative reports on the state of the life sciences coming out of the media like *The Financial Times* (e.g., Crow 2015) and *Investor's Digest* (e.g., Picardo 2015). Similar trends are evident in other high-tech sectors, exemplified by the recent valuations of social media platforms (e.g., Uber, Lyft, Airbnb, etc.; Keen 2015). But how does this relate to science and technology studies (STS) and to STS analyses of the bio-economy?

My aim in this article is to understand the seeming contradiction between high and rising financial valuations in the life sciences sector and its continuing failure to deliver on the promise of bountiful new products and services (see Nightingale and Martin 2004; Birch 2006; Pisano 2006; Hopkins et al. 2007; Mirowski 2012; Mittra 2016). What is so interesting here is that most life sciences firms are valued highly not because they have marketed products or services, but despite the inherent uncertainty

underpinning the development of said products and services (Hopkins 2012; Bratic, Blok, and Gostola 2014; Mittra 2016). This suggests that future promises are constitutive of value in the present. Several STS scholars have stressed the analytical importance of this "promissory" or "speculative" value in the bio-economy, although primarily within a theoretical framework built on notions of biological materiality, commodity production, and commodification (e.g., Waldby 2000, 2002; Rose 2001, 2007; Sunder Rajan 2006, 2012; Cooper 2008; Brown, Machin, and McLeod 2011; Brown 2013; Goldstein and Johnson 2015; Haw 2015; Petersen and Kisjansen 2015; Vora 2015; cf. Hoeyer 2009 and Birch and Tyfield 2013). In my view, however, this literature does not adequately address or explain the contradiction (i.e., between rising financial valuations in the life sciences and the failure to deliver on the promise of bountiful new products and services) I highlighted above, at least not by itself. Something more is needed.

In order to offer an alternative perspective, I focus on the "political-economic" side of the *bio-economy* rather than the "biological" or "material" side that dominates many current STS accounts. I specifically focus on the relationship between the firm—as a financial entity—and financial knowledges (e.g., accounting), financial practices (e.g., corporate governance), and financial actors (e.g., venture capitalists) in order to conceptualize value and valuation as resulting from a process of *assetization* (Birch 2015); that is, the turning of things into assets (cf. commodities). I examine, theoretically and empirically, the social practices and processes of valuation in the bio-economy, which are characterized by an active, ongoing, and performative *management* of value. This analysis contrasts with existing STS literature—mentioned above—that conceptualizes value as an intrinsic (even latent) aspect of biological materiality, commodity production, or commodification. In contrast to this perspective, my argument is that any theoretical approach to value in the bio-economy has to take into account the financial valuation of (life science) firms and their assets, rather than the intrinsic value of products, services, or intellectual property (IP) as commodities. Biotechnologies and bio-knowledges represent assets held by firms, which are themselves valued through financial investment practices, and thereby the "firm" ends up where most value is realized. As a result, value is constituted primarily by the *social practices* of the political-economic actors who *configure* the financial value and valuation of firms.

I begin my analysis with the firm instead of the "commodity" for two reasons. First, there is an overall dearth of products and services in the life sciences sector, with most firms never developing a marketed product; and

second, this lack of products has not stopped the global financial valuation of life sciences firms topping US$1 trillion recently. In light of this contradiction, I emphasize the processes of assetization and *capitalization* in value and valuation; that is, how technoscientific knowledges are turned into assets (i.e., resources that generate recurring earnings) and then capitalized (i.e., discounting future earnings in the present). My key claim in this article is that we need to theorize and analyze these processes in the bio-economy, directing our attention to political-economic knowledges, practices, and so on, in order to analyze value and valuation of assets as social practice. Commodification is important, certainly, but it is a sideshow to the implications of assets to an understanding of value and valuation, as evident in stock market valuations; consequently, much of the current STS literature on the bio-economy misses the very complexity of value and valuation in modern capitalism that they seek to conceptualize, precisely because of the emphasis on commodities, ''liveliness,'' materialities, and so on.

In order to undertake this analysis, I focus on a number of *political-economic* processes. I use political-economic here as a descriptive rather than analytical term to characterize social actors, knowledges, and practices involved in the extra-technoscientific configuration and reconfiguration of the bio-economy; that is, actors, knowledges, and practices on the ''economy'' side of the bio-economy concept. I start with a theoretical discussion of finance and STS in order to introduce readers to three key political-economic processes: financialization, capitalization, and assetization. I then analyze empirical material drawn from a number of in-depth interviews with political-economic actors (e.g., venture capitalists, stockbrokers, etc.) involved in financing UK life science firms. I finish with a discussion of the implications of my argument.

Finance and Science and Technology Studies

Scholars in STS turned their gaze toward finance well before the GFC. A range of literature started to appear in the early 2000s on the material and technoscientific underpinnings of finance and financial activity. Broadly labelled ''social studies of finance'' (e.g., MacKenzie 2009), this research, however, represents only a fraction of the work on finance at the interface of STS and cognate fields like innovation studies, management, economic sociology, economic anthropology, accounting, law, and so on (e.g., Miller and O'Leary 2007; Doganova and Eyquem-Renault 2009; Muniesa 2012, 2014; Ortiz 2013, 2014; Pistor 2013). It would be difficult to provide an overview of all this literature, but that is not my intent here. Instead, my

goal in this theoretical section is to discuss the literature on finance and the life sciences or bio-economy. My focus, highlighted in the introduction, is not the technoscientific underpinnings of life sciences financing, but rather how finance and financing (re)configures (bio-)technoscience. In this sense, I want to understand the political economy of technoscience, not the technoscience of political economy (Tyfield 2012a, 2012b; Birch 2013). Next, I discuss three key financial processes—financialization, capitalization, and assetization—that help in the rethinking of value and valuation in the bio-economy.

Financialization

In innovation studies and related fields like management studies, there is a growing interest in the financing of the life sciences (e.g., Pisano 2006; Andersson et al. 2010; Lazonick and Tulum 2011; Hopkins 2012; Hopkins et al. 2013; Styhre 2012, 2014, 2015; Martin 2015; Birch forthcoming). Much of this literature has been stimulated by events like the GFC and debates about the growing dominance of finance in the economy (e.g., Krippner 2005) and social life more generally (e.g., Birch 2015), or, more simply, the *financialization* of our economies and societies. This literature provides a series of important insights for anyone seeking to understand or conceptualize value in the bio-economy.

As STS scholars like Cooper (2008) theorize it, financialization is a response to the declining rate of profit that industrial economies experienced in the 1970s. Simply put, it refers to "a pattern of accumulation in which profits accrue primarily through financial channels rather than through trade and commodity production" (Krippner 2005, 174). As such, it involves "the growing influence of capital markets, their intermediaries, and processes in contemporary economic and political life" (Pike and Pollard 2010, 30). It is deeply entangled with the expansion of the knowledge economy, both as political-economic imaginary and as driver of science and innovation policies (Birch and Mykhnenko 2014). In reference to the bio-economy, Philip Mirowski (2012, 296) specifically characterizes the "biotech firm" as a "financial artifact." By this, Mirowski means that life sciences firms are not primarily configured as technoscientific organizations—that is, as producers of technoscience or technoscientific products—but, instead as financial organizations. This is evidenced, according to Mirowski, by the fact that "most biotechs never produce a drug or other

final product" (p. 295). He goes on to argue that biotech firms are, therefore, best thought of as Ponzi schemes.

A number of analyses support Mirowski's general point, including work by Nightingale and Martin (2004), Pisano (2006), Birch (2007, 2012), and Hopkins et al. (2007). To start, Pisano (2006) claims that the life sciences sector is characterized by firms *monetizing* knowledge, especially IP, rather than creating new products. As much existing research notes, the expansion of IP followed several significant political, legal, and financial changes in the 1980s designed to promote the life sciences (e.g., Birch 2006; Mirowski 2012; Berman 2014). According to Pisano (2006), monetizing IP was seen as the best way to finance long-term product development in the life sciences and involves financing research and innovation through licensing, partnerships, royalties, and so on (i.e., asset-based income) but not necessarily through product sales (i.e., commodity-based income). One consequence of monetizing knowledge, according to Andersson et al. (2010), is that life sciences financing ends up resembling a "relay" race; a financialized business model comes to dominate research and innovation strategies in which selling the firm before the development of a final product becomes *the* preferred option because it is less uncertain and hence more lucrative (see Hopkins et al. 2013; Styhre 2014).

Just as Powell et al. (2002, 292) point out, all financiers are engaged in an unusual relationship with life science managers because they have such a "terminal point in mind" (e.g., sale to other financiers, sale to large competitors, IPOs, etc.). In contrast to Mirowski (2012), however, it might be more apt to conceptualize the (re)configuration of research and innovation strategies in the life sciences resulting from financialization as a *reverse* Ponzi scheme; that is, it is the final private financier (e.g., late-stage venture capitalist) who either accrues the highest returns or nothing at all from their investment, while the first financiers (e.g., friends, family, government, etc.) accrue the least (see Hopkins 2012). This results from the relay process in financing (Andersson et al. 2010), since later financiers, who generally make larger investments, make their financial decisions based on the potential dilution of their investment resulting from the extent of previous investments and their ability to "add value" to the business concerned (Hopkins et al. 2013; Styhre 2015; Birch unpublished). It is important to note in this context that such strategies entail a specific (re)configuration of technoscience in the shape of an organizational entity (i.e., biotech firm) that can be capitalized as a financial artifact since it (currently) produces no products or profits and because it is uncertain whether it ever will.

Capitalization

This means that it is important to understand how the valuation of firms is and can be made by financiers, which brings me to the capitalization process.[1] Here I draw on a long tradition in political economy stretching from the work of Thorstein Veblen to more recent work on capitalization and finance (e.g., Veblen 1908a, 1908b; Nitzan and Bichler 2009; Muniesa 2012, 2014; Palan 2012). An emerging literature on the borders of STS and other disciplines integrates this tradition in their analyses of technoscience. For example, work by Fabian Muniesa (2012, 2014) is based on the notion of capital and value as *social practice*—that is, achievements of capitalization and valuation rather than as things (cf. concepts like "lively capital," as in the research in Sunder Rajan 2012). Consequently, this approach problematizes the notion of value as immanent or latent in material things (e.g., commodity) and/or discursive claims (e.g., hope); that is, there is no inherent or internal characteristic that constitutes value. Rather, capitalization necessarily entails a set of valuation practices bound up with monetizing knowledge in specific organizational forms and financialized business models, as well as the governance and management of the assets of those entities (cf. the production of commodities).

So, what is capitalization? To put it simply, it refers to "the present value of a [discounted] future stream of earnings" (Nitzan and Bichler 2009, 153), or:

> . . . the reduction of a stream of future earnings to their present value through the use of a calculative device (a discount rate) which signals how much a capitalist would be prepared to pay to receive a future flow of money. (Muniesa 2014, 40)

According to Muniesa (2012, 31), capitalization involves a dual process of valuation in which (a) the appraisal of the value of something (e.g., business entity) is simultaneous with (b) the construction of the thing to be valued (e.g., earnings). As a result, value involves a set of political-economic and technoscientific activities like accounting (e.g., Miller and O'Leary 2007), business models (e.g., Doganova and Eyquem-Renault 2009; Baden-Fuller and Morgan 2010), law (Pistor 2013), standards setting (e.g., Busch 2011), market regulations (e.g., Christophers 2015), and so on. It is important to unpack these various valuation practices—or how value is constituted and configured—at play in the bio-economy in order to avoid black-boxing value. As the previous discussion of financialization should indicate, the

starting point for understanding these valuation practices is theorizing the business entity (i.e., firm). As always, space constraints limit what I can do in this article. For that reason, I focus on two illustrative valuation practices: (1) future revenue models and formulae and (2) current revenue accounting.

First, there are a number of business models and business revenue formulae that represent practices to configure value and forms of value capture in the firm, especially in innovative sectors that are by their nature uncertain (Doganova and Eyquem-Renault 2009; Baden-Fuller and Morgan 2010; Doganova 2011). In her work, Liliana Doganova and collaborators define business models as "market devices"(Doganova and Eyquem-Renault 2009) and revenue formulae like discounted cash flow (DCF) as "valuation devices" (Doganova 2011). Both represent practices that construct and perform markets rather than "discover" them; they do so by defining and framing the future customer base, future revenue streams, future forms of value capture, and so on in order to enable the valuation of a business entity. As Baden-Fuller and Morgan (2010) note, however, there are numerous business models—as there are numerous revenue formulae—each with its own distinct rationale, forms of behavior, and so on (e.g., Wal-Mart vs. Google vs. McDonald's). In the bio-economy, for example, the supposedly dominant business model is the VC-backed, dedicated life sciences firm looking for an IPO exit (Pina-Stranger and Lazega 2011); this is more in theory than reality, however, since most financing does not come from VC and most firms do not end up entering public markets (see Hopkins 2012; Hopkins et al. 2013; Birch forthcoming).

Second, current accounting practices involve, as the name suggests, ways to account for value (e.g., Miller and O'Leary 2007; MacKenzie 2009). According to Donald MacKenzie (2009), for example, accounting practices involve a considerable amount of interpretation—they are *not*, in this sense, unambiguously or directly performative (cf. Callon 1998). Valuations could be based on current profit, earnings, cash flow, or something else entirely. A recent technical advisory by the accounting firm EY on changes to new revenue recognition standards, for example, notes that life science firms have to distinguish between IP licenses that provide "right to access" or "right to use" because of different revenue implications; that is, revenues over the license period versus those at the point the license is signed, respectively (EY 2014). Another example is the difference between the "book value" and "market value" of an asset (see Brealey et al. 2003). Book value refers to the value of an asset at point of purchase (i.e., historic, backward looking), while market value refers to an asset's value at current

market prices. The latter entails valuations using current "market prices" where this reflects an assumption that markets always price assets accurately and that value can be worked out from the price determined between two contracting parties with perfect information (Zhang 2011).

When it comes to the bio-economy, then, these valuation practices problematize inherent or embodied notions of value, especially through their focus on an organizational entity (i.e., firm) rather than commodity production. This is because a life sciences firm likely produces no products for sale and its likelihood of doing so in the future is highly uncertain, if not highly unlikely. In concluding this discussion, I want to stress that the configuration of value through these diverse valuation practices involves the transformation of something into a recurring source of revenue—that is, turning something into an "asset"—rather than its transformation into a commodity, which brings me to the final process I want to discuss in this section.

Assetization

As the above discussion should indicate, value needs rethinking in order to understand what gets valued (i.e., firm) and how (i.e., valuation practices); this, however, necessitates an examination of the coproduction of these practices with organizational forms and their governance. Understanding value in relation to organizational entities means focusing on (organizational) assets—which underpin their valuation—as opposed to commodity production. At present, most STS scholarship on the bio-economy has focused analytically on commodity production and the commodification of life, tissues, knowledge, and so on. This emphasis is, at least partly, the result of a concern with contrasting gift economies and commodification (e.g., Tutton 2011). However, there is an emerging literature that seeks conceptually to unpack assets in the bio-economy; for example, see the work of Birch and Tyfield (2013), Cooper and Waldby (2014), Lezaun and Montgomery (2015), and Martin (2015).

Assets are not new phenomena in wider political economy. Thorstein Veblen (1908a, 111), for example, referred to the capitalization process as the creation of an asset; that is, the transformation of something into property that yields an income stream (and not a commodity for sale). The difference between commodities and assets is best illustrated with an example; an asset is something like music copyright, while a commodity is more like a CD or downloadable song. In this sense, assets are distinct in a number of important ways. As *capitalized property*, assets may be tradable but they have other characteristics too (discussed below). They can also be

both tangible and intangible. Veblen, for example, was specifically interested in the capitalization of intangible assets, or what he called "habits of life" (e.g., loyalty, reputation, preferences, convention, etc.; p. 116). "Knowledge" can be added to these other intangible assets, although it has to be transformed into knowledge assets through various forms of IP rights (IPRs; Zeller 2008; Martin 2015). Rather than commodification, the creation of knowledge (or other) assets is more appropriately conceptualized as a process of assetization (Birch 2015); that is, the transformation of something (e.g., knowledge) into a revenue-generating and tradable resource. In order to understand how focusing on assets helps us to rethink value in the bio-economy, it is important to understand what makes assets distinct.

First, knowledge assets like IPRs entail new and different forms of control rights. According to Peter Frase (2011), IPRs give owners both exclusion rights, like other property (e.g., commodity), and the right to determine the use of copies derived from said asset. For example, buying a music CD does not give someone the right to copy that music and distribute it. Assets are, in this sense, constructs of law, which is something Pistor (2013) highlights more generally, and represent a set of contractual obligations and control rights. Second, according to Birch and Tyfield (2013), commodities and assets entail different demand logics: on the one hand, commodities tend to fall in price as demand rises since more producers are incentivized to enter the market; on the other hand, assets tend to rise in price as demand rises since assets are, inherently or constructed as, unique and difficult to replicate (e.g., there can be only one copyright to music by *The Beatles*). This is especially the case when it comes to knowledge assets that are configured as monopolies (e.g., IPRs), which then generate monopoly rents on the back of these monopoly rights (Fuller 2002; Zeller 2008; Birch unpublished).

Third, while asset prices may tend to rise as a result of their demand logic, this does not preclude the reverse in light of diverse valuation practices discussed above; for example, the valuation and management of value may involve attempts to increase value, to decrease value, to transform assets from one form to another (e.g., tangible to intangible), to transfer assets from one owner to another, and so on. Consequently, different political-economic actors have very different strategies when it comes to the time length they seek a payoff for (Styhre 2012). Finally, this implies that asset values and valuations are dynamic, in that they depend on active management and the obscuring of that active management; in his discussion

of financial assets, for example, Horacio Ortiz (2013, 2014) argues that "value creation"—as defined by financial managers—is an "ontology on which moral and political content rests, which implies that the value talked about really exists and can be created by the finance industry" (Ortiz 2014, 46). Value is, in this sense, both something to be created and something whose creation tends to be denied.

With these various points in mind, I conceptualize assetization as a process in which value is constituted by the management of value and valuation, especially as they relate to organizational entities and their capacities. As Styhre (2015, 57-58, 158) notes, management is a neglected issue in political economy because of its focus on production; this results in the "black boxing" of the business form, as happens with value. Styhre goes on to highlight the importance of "postinvestment processes" such as corporate governance and investor relations, areas that are largely ignored in STS scholarship on the bio-economy, with some exceptions (e.g., Tutton 2011; Martin 2015). In this sense, rethinking value entails understanding how assets are governed and managed within organizational entities, rather than how it is constituted or represented by biological matter, liveliness, surplus life, and so on.

Financing, Accounting, and Managing Value in the Bio-economy

The empirical analysis in this section draws on in-depth interviews with thirteen political-economic actors in the UK financial sector carried out in June and July 2012, along with an analysis of secondary literature dealing with life science financing. To avoid any confusion, these interviews were not part of an ethnographic study; instead, they represent an attempt to explore the political-economic processes, knowledges, and practices in the bio-economy. All interviewees were involved in the financing of the UK life sciences sector and included private financiers (e.g., venture capitalists, business angels); "market makers" (e.g., stockbrokers);[2] corporate lawyers; and other relevant actors (e.g., trade associations). The interviews concerned the impact of the GFC on the UK life sciences but also dealt with corporate governance, value, and valuation practices. My main concern in this empirical analysis is to examine the management and governance of value and valuation by these political-economic actors. Consequently, I focus on knowledges and practices of accounting, corporate governance, and management.

Financing the Bio-economy

The starting point for this analysis is the claim by Nightingale and Martin (2004) and Pisano (2006)—among others—that there has not been a "biotechnology revolution"—at least when it comes to the biomedical sector. There are two sides to this claim: first, that the technoscience has not lived up to expectations, which is perhaps to be expected; and second, that financial returns have not lived up to expectations. Overall revenues in the biomedical sector, for example, have been negative *ever since* the founding of Genentech in 1976 up until 2007 when publicly listed biotech companies (i.e., the largest) became profitable for the first time (Lawrence and Lahteenmaki 2008); however, the whole global industry only became profitable for the first time in 2009 (EY 2015a). Even this limited profitability, however, is dependent on a handful of very large biopharmaceutical companies (e.g., Amgen). Moreover, aggregate returns from financial investment in publicly listed firms have been poor (Pisano 2006). While some venture capitalists have made high returns (Hopkins et al. 2013), this has been highly selective. As one of the interviewees pointed out:

> I think there was a sort of great deal of interest in life sciences ten years ago because there was this belief that universities contained all these potential therapies which were not being exploited and they should be exploited and, you know, that they would be the start of some great revolution in life sciences worldwide. And I think that's actually a chimera; I think there were one or two good technologies around, but I think there's an awful lot of dross. (VC Investor K, July 3, 2012)

As evident in this quote and existing analyses of the bio-economy (e.g., Nightingale and Martin 2004), the sale of products has actually been a relatively unusual strategy in the bio-*economy*, limited to a few businesses, even if there has been significant technoscientific activity. As one interviewee put it:

> . . . this is not a popular view. We're commercial money and . . . when is the point that an asset ceases to be academic and starts to be a, really, a commercial asset, a business rather than a research project? And if you take—this is a personal view here—if you take much of what was being done five or seven years ago with life science businesses, it was research. It wasn't business, it was research. (VC Investor C, July 12, 2012)

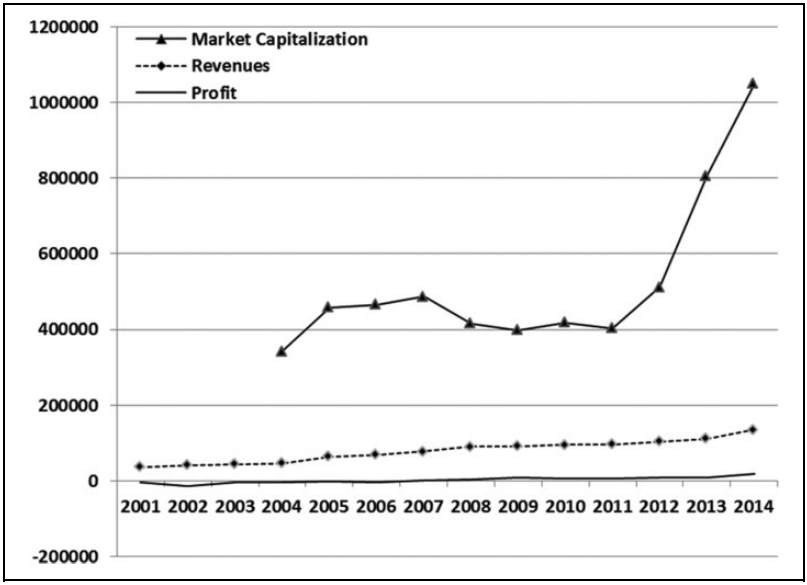

Figure 1. Global public biotech industry (US$ million). *Source*: Lähteenmäki and Lawrence (2005), Lawrence and Lähteenmäki (2008, 2014), Huggett, Hodgson, and Lähteenmäki (2009, 2010, 2011), Huggett and Lähteenmäki (2012), Huggett (2013), and Morrison and Lähteenmäki (2015); reproduced with my permission.

As such, understanding value and valuation in the bio-economy necessitates more than the study of scientific researchers; it also requires the study of firms and financiers. Understanding value as social practice—or valuation—as suggested by the work of Muniesa (2012, 2014) and others means analyzing how value and valuation are understood, accounted, and managed by these financial actors in the bio-economy. This examination needs to happen on at least two fronts:

(a) analyzing (financial) value from the standpoint of the trading of private and public equity of life science businesses (e.g., publicly listed shares and private investment) rather than only from the standpoint of the sale of commodities (e.g., revenues; e.g., see Figure 1) and
(b) analyzing value in terms of the tangible and, especially, intangible assets (e.g., knowledge, intellectual property, etc.) of these businesses (Birch and Tyfield 2013).

First, even where life science firms do develop marketed/saleable products like pharmaceutical drugs, value is not constituted (primarily) by the production of those drugs—which are relatively cheap to manufacture once developed—but (predominantly) by the ownership and control of assets (e.g., IPRs) that underpin those drugs. Value is constituted by the valuation of those assets. It is therefore important to analyze how an asset is different from a commodity (discussed above). International accounting standards (IAS) define an asset as:

> . . . a resource that is controlled by the entity as a result of past events (for example, purchase or self-creation) and from which future economic benefits (inflows of cash or other assets) are expected. (IAS 38.8; see http://www.ias plus.com/en/standards/standard37)

An asset is a "resource" that creates "future benefits"—it is both capital (i.e., productive) and property (i.e., tradable; Veblen 1908a). Consequently, intangible assets like IPRs are both a resource in commodity production and an income stream (e.g., licensing), representing knowledge monopolies that accrue monopoly rent (Zeller 2008). A monopoly means that businesses do not have to engage in competition in product or commodity markets. Moreover, as Fuller (2002, 36) notes, monopoly rent actually "'discounts' the future in favor of the past, in that payment is made for things already done." Consequently, it is not simply the future that is generative of value in the present, it is the past as well (enforced through property rights on previously undertaken activities).

The monetization of (intangible) assets is tied to financing strategies in the bio-economy. As noted in the theoretical discussion above, this monetization involves a complex relay of valuation practices, as successive financial actors seek to add value to their financial investments before passing it onto someone else. According to Andersson et al. (2010, 632), for example, financing is like "competing in a relay where handing the baton on to the next investor secures a (possible) realized gain in invested equity funds" (also see Hopkins 2012; Hopkins et al. 2013). As such, it is driven by the need to find a return from (intangible) assets that can pass through several investment rounds or achieve various milestones, returning value to financiers at each round or milestone rather than forcing them to wait for revenues from a final product. The needs of VC end up driving the search for specific exits that often entail the public flotation of businesses through IPOs (Pisano 2006; Hopkins et al. 2013). More recently, however, other exits have become increasingly common as a consequence of

changing business strategies and valuation practices. For example, one interviewee commented that:

> I think companies generally believe that undertaking expensive phase three trials is something they can't really do themselves. So what they've increasingly done is out-license their best assets to global pharmaceutical companies in exchange for royalties whereas a few years ago we'd have seen more companies wanting to do a whole lot themselves and take the drug to market. So we see very few companies now with a whole plan of doing phase one, phase two, phase three, take a drug to market. That is a strategy that's definitely changed. (Broker G, June 28, 2012)

The previous IPO exit strategy is increasingly limited by the lack of product revenues; instead, most life science businesses have to find ways to monetize their intangible assets by developing income streams from royalties, partnering, out-licensing, and so on (Yang 2014). Paradoxically, this means that there is less incentive to develop products and services (e.g., drugs) since the assets themselves (e.g., IP) can produce income (e.g., monopoly rents) and retain their value as capitalized property (Zeller 2008). This can be analyzed as a dual process involving the assetization of knowledge (i.e., turning it into IP) and the monetization of that knowledge asset as a source of value (e.g., out-licensing IP).

Accounting for Value in the Bio-economy

As the discussion above illustrates, rethinking value in the bio-economy entails incorporating the firms and their assets into the analysis, and not primarily focusing on commodities or commodification. As some recent work in STS shows (e.g., Lezaun and Montgomery 2015; Martin 2015), it is important to analyze how value is understood by financial actors and how they act on that knowledge. Accounting for the value of life science businesses, for example, requires an analysis of their (tangible and intangible) assets—which correspond to a set of liabilities (e.g., equity and debt)—and how these are conceptualized in corporate finance (e.g., Brealey et al. 2003). Understanding this financial knowledge helps in the conceptualization of valuation in the bio-economy as social practice, and it is something that Doganova and Eyquem-Renault (2009), Muniesa (2012, 2014), Ortiz (2013, 2014), and Doganova and Muniesa (2015) show in their various analyses of financial markets and valuation devices. In building on this literature, it is important to analyze how understandings of value and

valuation practices in the bio-economy are articulated, even coproduced. As discussed above, this means thinking about capitalization in the accounts of and accounting for value in the bio-economy, especially as this relates to intangible assets. Here it is worth considering (a) what is distinct about intangible assets, (b) how intangible assets are valued, and (c) what political-economic actors are involved.

First, assets can be tangible and intangible. Tangible assets include things like real estate (e.g., office space, lab facilities, etc.), machinery (e.g., lab equipment), and so on. Nowadays, however, intangible assets have come to be seen as more important in the valuation of businesses—and understood to be more important as capitalized property by financiers (Nitzan and Bichler 2009; Pagano and Rossi 2009). A report by the Organization for Economic Co-operation and Development (2012) identifies a range of things as intangible assets, including software and databases, brand equity, reputation, and so on. One important intangible asset is "goodwill," which covers everything not specifically identifiable elsewhere (Veblen 1908a; MacKenzie 2009; Palan 2012). According to MacKenzie (2009), goodwill represents the valuation of a business as a going concern (i.e., earning income) rather than the valuation of its assets if sold off. With the bio-economy, the most important intangible asset is knowledge, although, this represents more than just IP, as this interviewee illustrates when discussing bankruptcy:

Interviewer: Right. In terms of companies that go bust, is that generally what happens then, the intellectual property assets get bought up by somebody or other and . . . ?

VC Investor: Yes, but it's normally for pennies. And the problem is that actually when they go bust the employees and all the knowledge disappears, typically within the administration. So actually you have a patent or some software code or whatever it is, but actually a lot of the value's walked out the door [in people's heads]. (VC Investor B, June 11, 2012)

Generally, an asset is valued in terms of the expected benefits a business will derive from it in the future (i.e., future earnings), worked out through specific valuation practices such as DCF analyses (Doganova 2011), or other methods (Bratic, Blok, and Gostola 2014). In this way, value is constituted by valuation practices focused on an organizational entity (i.e., firm) and not on the value latent or inherent in a commodity. For example, Muniesa (2012) quotes an early twentieth-century Harvard Business School professor, who says: "the business is the instrument which creates the

earnings, and the valuation of the business is the valuation of this instrument'' (p. 30). Such valuation centers on assets, not commodities, for example, Veblen (1908a, 111) describes the value of assets as the ''measure of the income which they may yield to their owner.''[3] Moreover, valuation practices are not (primarily) centered on actual product sales, as one interviewee outlines:

> We're generally not looking for an IPO [initial public offering] exit, so our focus is to find companies which are developing a disruptive technology where the disruption is sufficiently apparent that it will trigger a strategic acquisition by an incumbent in the market ... So the acquirer is not buying your revenue, a multiple of that, they are strategically acquiring you because they don't want their competitors to acquire you, because that will threaten their market share, or they want to acquire you because they can threaten their competitor's market share—so it's a strategic acquisition. (VC Trust Investor E, June 27, 2012)

Second, the notion of intangible assets has been around for over a 100 years. As noted above, what is ''owned'' when it comes to assets is their ''earnings'' (Palan 2012). This means that companies can and are valued in relation to future earnings rather than current earnings. However, these future earnings may not relate to any form of commodity production but reflect financial judgments about future income from and future rises in the value of a firm's assets, as well as the amortization of costs (e.g., expenses like depreciation; MacKenzie 2009, 112-13). What this implies is that focusing on commodity production and commodification misses much of the complexity of value in the bio-economy, especially in terms of accounting for the valuation of intangible assets.

Accounting for assets, in general, is not an objective or neutral measure of some latent or inherent quality of biology itself. Any analysis of value in the bio-economy has to look at a range of valuation methods—for example, asset, income, or market approaches (e.g., Bratic, Blok, and Gostola 2014)—as well as different valuation expectations. During one interview, for example, an informant noted the different valuation expectations of different political-economic actors when it came to differentiating between exits (e.g., trade sales vs. IPOs). The informant noted that:

> And also, to get back to Jay's [pseudonym] point a bit earlier, there's a different valuation metric in terms of the way industry will value business and an investor. So you get a materially higher premium or exit value if you

> sell [i.e., trade sale] than if you trade the shares [i.e., IPO]. (Broker H, June 29, 2012)

Here the "premium" refers to the valuation expectations of different actors; for example, an "industry" buyer (i.e., other life science or pharmaceutical company) has a different understanding and expectation of the value of a firm in a trade sale than a general "investor" (e.g., institutional investor) in an IPO. According to another informant, for example, "trade buyers trade on superior knowledge" since "industry is in a better position to judge the merit of individual biotech programs" and its potential market (Broker I, June 29, 2012). In this sense, different actors can make very different valuations of a business and its assets because those different actors judge the realization of value differently; for example, asset value, earnings potential, or market share (Bratic, Blok, and Gostola 2014).

Finally, as the existing literature on valuation practices illustrates (e.g., Muniesa 2012, 2014; Ortiz 2013, 2014), the value of intangible assets is constituted by a diverse *range* of actors who deploy different knowledges and practices. Some of the key social actors include financial intermediaries (e.g., analysts, stockbrokers, investment banks, etc.). As one informant noted, these intermediaries are "essentially the conduit between the company and the pension fund managers" (Broker G, June 28, 2012). Other informants claimed that these pension funds, and other institutional investors (e.g., mutual, insurance funds), are "the market" (Broker H & Broker I, June 29, 2012). As Ortiz (2013) argues in relation to financial markets, such intermediaries end up representing "investors," and thereby both create and constitute value through a number of practices that tie them into a broader financial ecosystem. The ecosystem comprises actors who make valuation claims (e.g., stock analysts), value-measuring knowledges and techniques (e.g., DCF, Doganova 2011), and practices to actively manage value. An example from this ecosystem are stock analysts firms like Peel Hunt LLP, which provide research notes on companies (comprising an array of different acronyms such as return on assets, return on equity, enterprise value by earnings before interest, taxes, depreciation, and amortization, enterprise value by sales, etc.) that are then used to make and manage investment decisions (e.g., Peel Hunt 2011, 2012).

Managing Value in the Bio-economy

As mentioned above, in rethinking value in the bio-economy it helps to focus—both theoretically and empirically—on how political-economic

actors (e.g., financiers, managers) understand value and how they make valuation judgments. For example, a recent report by the accounting firm EY (2015b, 4) on capital allocation strategies in the life sciences comments that:

> As management teams debate different approaches to value creation, they will need to consider multiple options simultaneously, ranging from deploying capital via share buybacks or dividends to potentially transformative acquisitions and divestitures.

As this quote illustrates, understanding and judging value are not static or onetime events; they involve the continuous management of value, especially through the management and governance of the assets that constitute organizational entities (e.g., biotech firms). This is because, as Mirowski (2012) points out, most biotech firms have not—and will likely never—produce a product for sale. In this sense, STS scholarship on value in the bio-economy needs to start to incorporate assets into the mix, as some scholars have started to do already (e.g., Birch and Tyfield 2013; Cooper and Waldby 2014; Lezaun and Montgomery 2015; Martin 2015).

In considering the management of value, a useful place to start is with the issue of "materiality," but not as STS scholars often theorize it. According to Pisano (2006, 140), materiality is a term used in corporate governance to define "[financial] disclosure rules that require companies to make public information that could have a *material impact* on the financial prospects of the enterprise" (my emphasis). One informant defined materiality in similar terms, as follows:

> Any material ... Any development in your business that might have a material effect on your share prices actually is what it [materiality] typically means, anything north of five percent or certainly 10 percent. (Specialist Lawyer F, June 27, 2012)

As Pisano (2006, 144) also notes, "there are detailed disclosure rules regarding financial information, detailed rules regarding how certain transactions should be accounted for and valued, and standards for valuing certain physical assets." These legal requirements configure how value can be understood, how it can be assessed, and how it can be managed; as such, they illustrate how assets are legal constructs as theorized by Pistor (2013). For example, the previous informant also explained why such materiality is important for life science firms:

> And that's quite a difficult to work out [5 percent to 10 percent price impact], particularly in this sector because often companies announce good news and nothing happens to the share price. They announce bad news, it collapses. It's quite ... I think the other thing is there's an element of ... The element that if you as a company, a smallish company or a mid-size company in this sector listed on the public market, there's this sort of sense that if you're not constantly pumping out news your share price just drifts down because there's nothing ... there's nothing to make it do anything else if you see what I mean. And that is a bit of a clash with all your ethical obligations if you're running a trial [since you cannot release any information until the end of the trial]. (Specialist Lawyer F, June 27, 2012)

As a result of the legal requirements to consider the material implications of their decisions, life science managers become more attuned to the expectations of financial market actors (e.g., venture capitalists, investors, etc.) than to technoscientific actors (e.g., scientists). This is exemplified by an EY (2015b, 5) report that extols the notion that life science managers need to "think more like investors than managers" in order to align managers' and investors' conceptions of value.

Bearing this in mind, value and valuation in the bio-economy are not simply hype or speculation or promises; value is, rather, constituted by specific forms of knowledge and practice that are necessary to make, govern, and manage valuation judgments. For example, materiality—in the financial and legal sense discussed above—involves the disclosure of information that is then used to make valuations about a particular life science company. Managing this information is part of managing value, since the release of (material) information can have effects that can be quite dramatic for small life science firms. This highlights the importance of "postinvestment decisions" discussed by Styhre (2015). For example, many life science firms delisted from the London Stock Exchange and alternative investment market after the onset of the GFC because they could no longer manage their value on a public market. As one informant highlighted:

> Well, a lot will delist because they're not raising the money, it might be finding the corporate governance and the reporting requirements too onerous, too restrictive, too difficult, and too threatening. (Venture Debt Investor D, June 26, 2012)

Other informants also highlighted the implications of these reporting requirements:

> As a public company you have an absolute obligation to disclose publicly to the market anything good or bad that may significantly affect your business prospects and/or share price, and, you know, for a smallish company that can be catastrophic if it's bad news. (Specialist Lawyer F, June 27, 2012)

Consequently, life science firms are caught between the requirement to release both "positive" information and "negative" information, even though it is likely only the latter that has an impact on value (e.g., share price)—and in a negative way, moreover. What becomes evident when considering this form of financial materiality is that value and valuation involve quite specific practices like investor relations, corporate governance, and so on. For example, one informant noted:

> That was, I guess, part of the problem that you had a large number of US companies come and list over here. The management didn't spend time by coming, frankly, to visit investors. They came over twice a year and they didn't commit a significant amount of time to building relationships, building long-term relationships. And so when the going gets tough they've got nothing to fall back on. So there's a kind of mentality now which is why are these companies coming to list over here and they've got to have very, very sound reasons that they want to have and then they have to make sure they commit to coming over here very regularly. (Broker G, June 28, 2012)

As this quote shows, value cannot be reduced to the biological, lively, embodied, or material qualities of commodities. Rather, and as another informant noted, the lack of trading information (e.g., earnings from product or services sales) means that life science firms are dependent on "managing sentiment" through the strategic release of other information (e.g., patenting activity, partnership activity, licensing activity, etc.):

> I think that it's very hard to … I think it's very hard for … I mean, if it's premarket, therapeutic business, it's incredibly hard to make it work on the stock market for two reasons, you've got no trading data, you know, regular data that you can point to to maintain competence in the business. So the only thing you can do is once in a while you can say that this has been patented, or that's gone through this trial or the other trial or this major pharma is talking to you. And those type of events tend to be rather unpredictable and quite lumpy. And therefore you've got to spend a huge amount of time managing

> sentiment and, you know, maintaining investor interest and the whole mindset of the investor, public market investor, is against long term patient capital, you know, because … you know, the sheer arbitrage of … around, you know, having to have a liquid share price mitigates against that. (VC Investor K, July 3, 2012)

The provision of information and "management of sentiment" illustrates why assets (e.g., IPRs, licensing, partnerships, etc.) are so important in the valuation of life science firms (cf. product sales); in effect, it is the information about assets and how that information is disseminated, analyzed, and understood that constitutes valuation, and hence value, in the bio-economy. For example, an informant emphasized the centrality of assets in business strategies as a result:

> I think companies generally believe that undertaking expensive phase three trials is something they can't really do themselves. So what they've increasingly done is out-license their best assets to global pharmaceutical companies in exchange for royalties whereas a few years ago we'd have seen more companies wanting to do a whole lot themselves and take the drug to market. So we see very few companies now with a whole plan of doing phase one, phase two, phase three, take a drug to market. That is a strategy that's definitely changed. The focus has shifted more towards how close are we to profitability? So it's sustainable profits is like a key focus rather than delivering value from the pipeline because investors don't value sort of R&D projects that are pre-phase three essentially. And so it's all about kind of keeping costs under control, maximizing the revenue we can generate from our lead assets, acquiring companies that have got royalty streams that bring in royalties on drugs that have already been launched. And I think that private companies' focuses has kind of shifted much more onto like what do we need to do to kind of sell ourselves because IPO is just not an option right now. (Broker G, June 28, 2012).

This perspective is reinforced by two issues currently underresearched in STS analyses of the bio-economy. On the one hand, a report from accounting firm EY points out that "investors typically assign little value to products under development" because of "high failure rates" (EY 2015b, 6). On the other hand, Styhre (2014, 6) argues that where there is limited information about a company's assets it is difficult "to attract anyone with the skills [e.g., analysts] to calculate properly to make an investment in the venture." As a result, the valuation of life sciences firms depends on the valuation of their assets by experts (e.g., stock analysts) in the valuation of life sciences

firms and the management by life sciences firms of the information these experts receive, rather than simply on revenue data from product or service sales.

Conclusion

My starting point for this article was the contradiction between the rising market capitalization of life sciences sector and the continuing dearth of marketed products and services in the sector. Theoretically I sought to go beyond the existing STS literature on the bio-economy that has "posited a transformation of modern capitalism without due attention to *the transformation of economic and financial processes in modern capitalism*" (Birch and Tyfield 2013, 301). In particular, I unpacked value and valuation as a set of social practices, rather than focusing on commodification and commodity production as most STS literature has done so far (e.g., Waldby 2002; Sunder Rajan 2006, 2012; Rose 2007; Cooper 2008). Consequently, I sought to treat the firm, its assets, and its valuation as an important object of study. In order to do this, I discussed a number of specific political-economic processes in modern capitalism in order to rethink how value is conceptualized in debates around the bio-economy. Conceptually, I focused on financialization, capitalization, and assetization; each process provides a useful insight into the conception of value and valuation in STS analyses of the bio-economy (and more broadly). Empirically, I illustrated how political-economic rather than "technoscientific" actors understood, assessed, and managed value in organizational entities (i.e., biotech firms).

Two important implications emerge from this article for how we understand value in the bio-economy. They both relate to understanding value as a social practice (i.e., valuation—Muneisa 2012, 2014), requiring an examination of its configuration resulting from political-economic and technoscientific constitutive elements. First, this configuration consists of legal rights and obligations, such as property rights to knowledge (i.e., IPRs; Zeller 2008; Pistor 2013), as well as organizational and managerial practices (e.g., corporate governance, accounting) that enable the monetizing and capitalizing of knowledge through specific organizational entities (e.g., biotech firm; Mirowski 2012). As a result, it is just as (if not more?) important to theorize value in the bio-economy in terms of financialization, capitalization, and assetization as it is to theorize it in terms of concepts more commonly found in the STS literature on value, such as commodification, liveliness, surplus vitality, and suchlike. These former processes provide STS scholars with a new set of analytical tools to unpack what is

going on when investors, financiers, managers, scientists, and others frame, make, govern, or manage the value of technoscience.

Second, understanding value in this way necessitates looking at the political-economic actors who have a say in the creation of assets, such as venture capitalists, hedge fund managers, asset managers, and so on. Consequently, this conception of value requires that STS scholars develop competencies in new fields (e.g., accounting) and areas (e.g., different techno-economic configurations to turn things into assets). It is important to note that this is different from the existing work on the social studies of finance, since it involves more than turning STS existing perspectives onto new topics (e.g., finance). Instead, it means analyzing how changing political economy—as epistemology and practice—configures research and innovation in particular ways (Mirowski 2011; Tyfield 2012a; Birch 2013). In this article, I have focused on how the understanding, governance, and management of value are configured by particular legal rights and privileges (Styhre 2015), political-economic knowledges like "capitalization" (Muniesa 2012), the structure and governance of organizational entities (Mirowski 2012), and financing instruments like VC (Andersson et al. 2010).

As this article has illustrated, the configuration of value is dynamic in that there are different stages in the valuation process (e.g., earlier to later in the value chain)—as well as different geographies, which I have discussed elsewhere (Birch 2012)—and analyzing these different stages might help to link better the "bio" and economy in the STS theorizing of the bio-economy. For example, important questions such as "at what point and how does biological potential turn into income-generating assets?" need answers, and that means that STS scholars have to engage rigorously with contemporary political economy, in both an intellectual and empirical sense.

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Notes

1. Current science and technology studies analyses of the bio-economy have engaged with the concept of capitalization in certain ways. For example, a number of scholars have theorized the capitalization of life, vitality, biology, hope, and so on. (e.g., Waldby 2000; Rose 2007; Kent 2012; Sunder Rajan 2012; Martin 2015). However, it is not always clear how this concept is being deployed, analytically speaking, by these scholars. It seems to be used in the sense of describing the transformation of something (e.g., life, tissue, etc.) into capital, although this then tends to treat capital (and value) as a "living thing" embodied in the commodity form; this is evidenced by the development of concepts like "lively capital" (Sunder Rajan 2012).
2. A "market maker" is defined as a financial intermediary who sits between markets participants who are (a) looking to buy and (b) looking to sell. Market makers enhance market liquidity by both buying and selling from these participants, seeking to make a profit from the buy–sell spread.
3. While some of these points might sound very much like Sunder Rajan's (2006) concept of "biocapital," it is important to emphasize that these valuation practices are not particular to the bio-economy—they are undertaken across sectors.

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